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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Process for Biological Waste Air Purification by Means of a Percolation System

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**Process for biological waste air purification by means of a percolation system**

Abstract

The waste air stream to be purified is passed through a percolation system fed with a washing fluid and serving at the same time as a carrier body for a microorganism culture which degrades the pollutant, the waste air stream and the washing fluid being passed through the percolation system in co- and counter-current in periodic alternation.

(Fig.)

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The invention starts from a process for biological waste air purification and the use of a percolation system, wherein the waste air stream is passed through a percolation system fed with a washing fluid and serving at the same time as a carrier body for a microorganism culture which degrades the pollutant. Processes of this type have been described, for example, in the article by H. Brauer, Umschau 1984, Issue No. 20, page 598, and in EP-A 100,024 and EP-A 133,222. In this case, the washing water is passed through the percolation system in co- or countercurrent with the waste air which is to be purified. As carrier bodies, for example, activated carbon or hollow bodies of plastics such as polypropylene, polyamide or polyethylene are used. A biofilm of adapted microorganism cultures gradually grows on the surface of the carrier bodies. During the passage of the waste air through the percolation system, waste air constituents are, on the one hand, washed out by the washing fluid and, on the other hand, also absorbed directly by the microorganisms. Biological waste air purification has proved particularly suitable when the pollutant concentrations remain more or less constant, that is to say when no load fluctuations occur.

This is the starting point of the invention. It is based on the object of developing a biological waste air purification process of enhanced flexibility, so that reliable adherence to preset limits can be ensured even

in the case of varying loading of the waste air with pollutants. In particular, a surge load with twice the pollutant concentration should still be intercepted.

Starting from the process described at the outset, this object is achieved according to the invention when the waste air stream and the washing fluid are passed through the percolation system in co-current and in counter-current in periodic alternation. This means that there is a periodic change-over between the co-current and counter-current procedures.

The frequency for the alternating co-and counter-current procedures is advantageously in the range from 0.2 to 2 changes per hour.

The carrier body used is preferably a reticulated polyurethane foam which can be partially coated with carbon powder fixed to the surfaces of the foam skeleton. Advantageously, the carrier body is inserted into the percolation tower in the form of a polyurethane foam mat rolled up to give a cylindrical body.

According to a further development of the invention, the washing fluid is recirculated through the percolation system and passed through a purification filter which contains the same carrier body with immobilised microorganisms as the percolation system. In this case it is advantageous when the purification filter is likewise designed as a percolation system and is operated in such

a way that the prepurified gas leaving the first percolation system is passed in co-current with the washing fluid through the second percolation system.

The process according to the invention has proved especially suitable in the separation of dichloromethane from a waste air stream.

By means of the invention, the following advantages are achieved:

- Because of the alternating co-current and counter-current procedures, a better purification performance can be achieved. Surge loads can be reliably intercepted. The biomass necessary for the purification forms in this procedure in the upper and lower parts of the percolation tower.

- In the process variant with a downstream second percolation tower as a purification filter, the biomass is formed mainly by pollutants which, in the counter-current procedure, pass with the washing fluid (water) into the second percolation system and are degraded therein. In this way, the pollutant stream is distributed over both percolation systems and can be influenced via the circulating water rate.

- The use of reticulated polyurethane ether foam has the advantage that this material requires only about

3% of the reaction space and does not contain any "dead" spaces. Moreover, the flow resistance is markedly less than in other percolation systems. The free space is therefore available for both the gas purification and the growth of biomass. In this way, a longer service life with a significant saving of purification cycles for the carrier material is achieved. The frequency of required purification cycles depends on the nature and quantity of the pollutants fed, in particular on the carbon content thereof.

- The use of wound-up polyurethane mats as the carrier material allows easily effected mechanical cleaning without loss of carrier material and of its biological purification capacity. Because of its skeleton structure, the carrier material is almost dimensionally stable even in the moist state and has a very low density.

- In the removal of dichloromethane (DCM) from a waste air stream, it was possible to achieve particularly high degradation rates. The purification performance amounted to 90% and more, depending on the raw gas concentration. In this way, it has been possible, for example, to achieve values significantly below the limits now demanded by the German Clean Air Regulations (20 $mg/m^3$) at starting values of 200 $mg/m^3$ in a gas stream of 6 $m^3$/hour.

The invention is explained in more detail below by reference to an illustrative example. The drawing shows a flow diagram of the process according to the invention.

The waste air to be purified is passed via the line 1 through its three-way valve 2 into the percolation tower 3. The prepurified air leaves the percolation tower 3 through the line 4 and is fed to a second percolation tower 5. The line 4 is connected via a three-way valve 6 to either the upper end or the lower end of the first percolation tower 3.

The washing water for operating the percolation tower 3 is delivered by means of the pump 8 from a mixing tank 7 through the line 9 to the spray nozzle 10 in the percolation tower 3. At the lower end of the percolation tower 3, the washing water runs via the line 11 to a pH value-measuring point 12 and is pumped from there by the pump 13 to the spray nozzle 14 of the second percolation tower 5. From there, the washing water flows back into the mixing tank 7 through the line 15. About 1% strength aqueous soda solution, which optionally further nutrient components such as urea or other nitrogen-containing substances as well as phosphates, is pumped by means of a pump 17 from a stock tank 16 into the mixing tank 7. Fresh water is fed via the line 18 to a further stock tank 19. Excess water flows out of the stock tank 19 through the line 20. Excess water from the mixing tank 7 is discharged via the line 21. A stirrer 22 is installed in the tank 7 for mixing.

The gas feed and discharge in the first percolation tower 3 is effected, as already described, by means of electrically switchable three-way valves 2 and 6. The valves 2 and 6 are switched over at a preset frequency of between 0.2 and 2 cycles per hour in such a way that the gas flows through the percolation system alternatively in co-current and in counter-current to the washing water. The connections here are such that, when the feed line 1 is connected to the upper end of the percolation tower 3, the lower end is connected to the line 4 leading to the second percolation tower 5 and, if the line 1 is connected to the lower end of the tower, the upper end is connected to the line 4. In the second percolation tower, the prepurified gas flows in co-current with the washing fluid. The purified gas flows out through the line 23 downstream of the second stage. In the alternating co- and counter-current procedure in the first percolation tower 3, a sufficiently large quantity of an adapted mixed microorganism culture is maintained in an active state in both the upper and the lower region of the percolation system, so that the microorganisms are always alternately exposed to a feeding phase and a starvation phase. The starving microorganisms can intercept the concentration peaks in the event of surge loads.

As already described, the washing fluid is circulated through the two percolation towers 3 and 5, a purification taking place in the second tower. The percolation tower 5 in the second stage thus has a dual function; it serves, on the one hand, for final purification of the

gas and, on the other hand, for purification of the washing fluid. This purification effect is important, in as much as the washing water, coming from the first tower in the counter-current procedure, contains a pollutant concentration corresponding to the phase equilibrium, which pollutants are degraded while passing through the second percolation tower 5. On the other hand, the gaseous pollutant contents, which is briefly increased in the change-over phases of the three-way valves 2 and 6, is reduced in the second stage, in addition to the final purification of the gas.

The percolation system 24 in the first tower 3 consists of a wound-up mat of reticulated polyurethane foam. The PU foam here forms a skeleton of thin small rods of approximately triangular cross-section, taking up about 3% of the total volume. Because of the reticulation, there are no membranes between the cells and hence also no closed cavities or niches. As a result of the skeleton-like structure, the material is largely dimensionally stable even in the operating state.

The external dimensions of the mat unit are, for example, 5 x 100 x 200 cm. These units can be sewn up along the 100 cm edges to give mats of any desired length. The first and last mat units are flattened along the 200 cm edge so that, when the long mat is wound up upon a winding core, formation of gaps is avoided. The winding-up produces an almost cylindrical block of the polyurethane carrier material, having a height of 100 cm and a

diameter of any desired magnitude. These blocks can then be stacked on top of one another in the percolation tower 3 up to the desired height. The interspace between the percolation block 24 and the inside wall of the tower 3 is filled with an inflatable sealing mat 25. It consists of an annular double-walled sleeve, whose edges are welded up. The sealing sleeve 25 laid around the percolation system 24 is then filled with air through a small connecting tube and thus seals the interspace between the percolation system 24 and the inside wall of the percolation tower 3. As a result, the waste air to be purified is forced to flow through the percolation system 24, whose surface is colonised by microorganisms.

The percolation system 26 arranged in the second percolation tower 5 is in its structure identical to the first percolation system 24. However, it has in general a smaller height and is operated exclusively in co-current; that is to say the gas and water streams coming from the first percolation tower 3 are passed downwards through the percolation system 26.

Example

Using the unit described, dichloromethane was removed from a waste air stream. Dichloromethane (DCM) was uniformly fed via a gas-washing bottle which was filled with a defined quantity of DCM, held at a constant temperature (about 10°C) by external cooling water and carried a flow of a defined air rate (about 1 l/h) in

fine bubbles. This air laden with DCM in accordance with saturation was passed into the feed line 1, and a DCM concentration of about 300 mg/l was thus set. The 3-way valves 2 and 6 controlled by a timer effected the change-over of co-current and counter-current procedures in the percolation tower 3 in a rhythm of about one hour, that is to say the DCM-laden air and the washing fluid with added soda solution of about 170 l/h passed the percolation system 24 alternatively in co-current and counter-current.

The pH value of the washing fluid running out at the bottom was measured at the measuring point 12, and it was then fed for final biological purification to the second percolation tower 5. This final purification is of great importance when the apparatus operates in the counter-current phase, because the washing water absorbs about 5 mg/l dichloromethane from the laden air. When sprayed onto the first percolation tower 3, this amount would partially be released again to the purified air and thus reduce the efficiency. The final biological purification in the second percolation tower avoids this disadvantage. While the washing water passes through the first tower 3, the pH value falls from about 8.1 to about 7.2, and by about 0.1 in the final purification. The original pH value is restored by pH-controlled addition of 1% strength soda solution.

For working, the microorganisms additionally require nitrogen and phosphorus and diverse trace elements.

Nitrogen and phosphorus were added in the form of urea or nitrate (0.2 g/l) and $K_2HPO_4$ (0.1 g/l) simultaneously with the 1% strength soda solution. The addition of 60 ml of nutrient salt solution was carried out discontinuously from a 60 l stock tank which was charged with about 5 l of potable water per hour. The pressure drop of the air during the passage through the apparatus was 30 mm or 35 mm water gauge at 10 $m^3$/h air throughput. No measures were taken for cooling or heating the large parts of the apparatus. The reaction temperature was thus identical to the room temperature (20° to 25°C).

The DCM concentration before and after the purification was measured by means of a flame ionisation detector. At a superficial loading of 140 $m^3/m^2$ h on an inlet concentration of about 300 mg/$m^3$ of DCM, the DCM concentration in the pure gas, that is to say in the outlet line 23, was about 10 mg/$m^3$. It was possible to maintain the requirements of the German Clean Air Regulations for class 1 (maximum 20 mg/$m^3$) even at surge loads of twice the concentration.

The PU carrier material used in this test for the percolation systems 24 and 26 was immersed for pretreatment into a suspension of specific DCM-degrading microorganisms and then inserted into the gas column. Microorganism cultures suitable for this purpose are described in the literature (see, for example, Kohler, Staub et al., J. Gen. Microbiol. 132, 2837 to 2843 (1986)).

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Patent Claims

1. Process for microbial separation of gaseous organic pollutants, especially chlorinated hydrocarbons, from a waste air stream, wherein the waste air stream is passed through a percolation system feed with a washing fluid and serving at the same time as a carrier body for a microorganism culture which degrades the pollutant, characterised in that the waste air stream and the washing fluid are passed through the percolation system in co- and counter-current in periodic alternation.

2. Process according to Claim 1, characterised in that the frequency of the alternating co- and counter-current procedures is in the range from 0.2 to 2 changes per hour.

3. Process according to Claim 1 to 2, characterised in that the carrier body used is reticulated polyurethane foam.

4. Process according to Claim 3, characterised in that a polyurethane foam mat rolled up to give a cylindrical body is used as the carrier body.

5. Process according to Claim 1 to 4, characterised in that the washing fluid is recirculated through the percolation system and passed through a purification filter which contains the same carrier body with

immobilised microorganisms as the percolation system.

6. Process according to Claim 5, characterised in that a further percolation tower is used as the purification filter and that the gas leaving the first percolation tower is passed in co-current with the washing fluid through the second percolation tower.

7. Process according to Claim 1 to 6, characterised in that dichloromethane is removed from a waste air stream.

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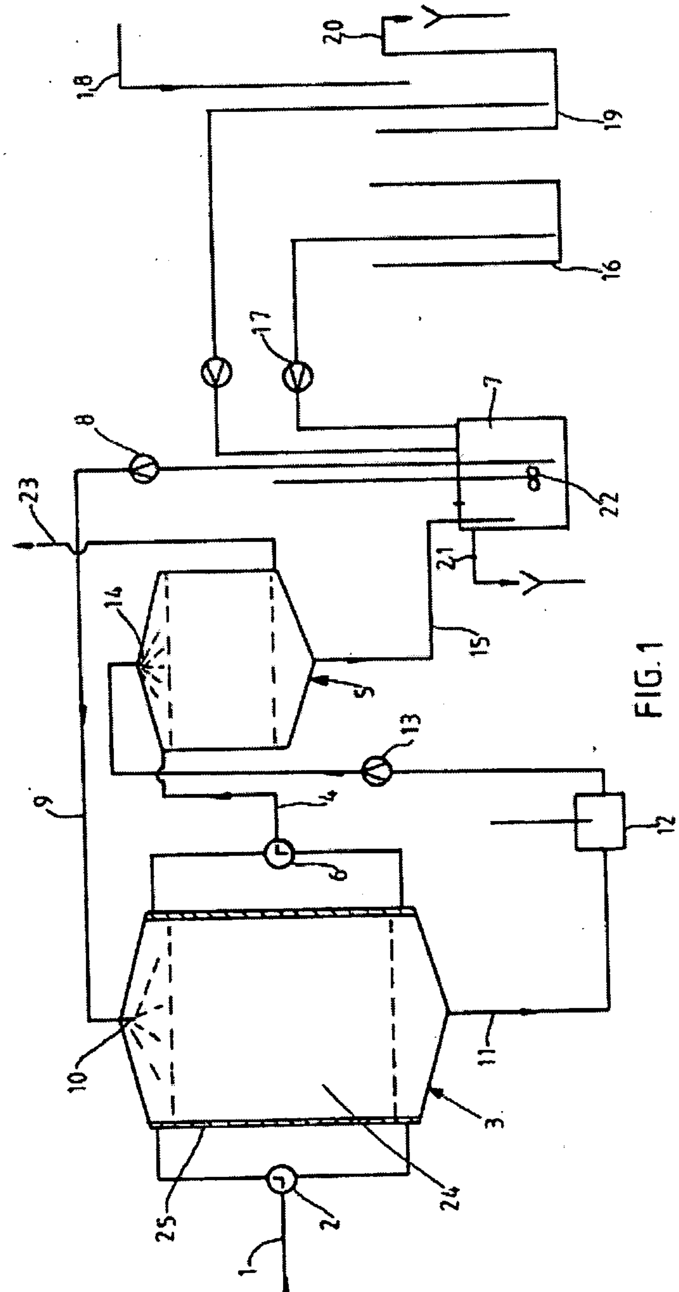


FIG. 1

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